As in other cases, the Cayuga relics cannot all be classified, and some are found which are sufficiently puzzling. Among these are some of the ruder implements. These may be passed over now, but the foregoing account will show what may sometimes be done in a short time in a field supposed to have been exhausted.

DAYS AND NIGHTS BY THE SEA.[1]

BY FRANCIS H. HERRICK.

FOR one who has spent his life inland, a visit to the sea and especially to the tropical sea is an event to date from. The revelation of a new world awaits him. Strange forms innumerable meet him at every turn, and he soon comes to realize that the sea is the great home of life.

The simple outfit of thirty years ago is utterly inadequate for the student of nature of to-day who hopes to add anything of importance to our knowledge of the organic world. He needs not only good microscopes, drawing materials, ample aquaria and dredging apparatus, but a large assortment of chemical reagents, the uses of which in the preservation and study of living matter has almost revolutionized the science of biology.

Nearly all marine animals discharge their eggs into the water in vast numbers, and the young which are hatched from them, in most cases, lead an independent swimming life at the surface of the ocean. This locomotor larval period as it is called, may extend over weeks or months, and is shared by animals which in the adult state have the most diverse habits, such as the coral, the barnacle, and the mussel, which are firmly anchored to some solid support, the starfish and sea-urchin, the jellyfish and annelid, the crabs and prawns, the salpas and amphioxus; and also the fishes, the highest type of marine life which pass their early stages at the surface of the

[1] Part of a lecture delivered in the "University Lecture Concert Course," Jan. 31, 1889. Western Reserve University, Cleveland, Ohio.

PLATE XIX.

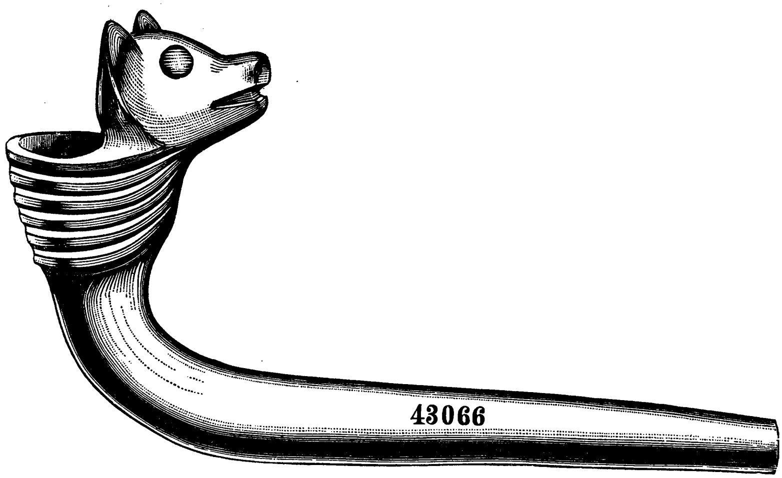

Fig. 5. Clay Pipe.

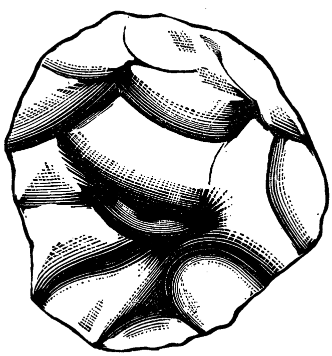

Fig. 6. Gambling Flint.

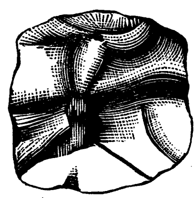

Fig. 7. Gambling Flint.

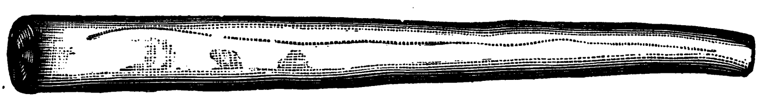

Fig. 8. Horn Implement.

CAYUGA INDIAN RELICS.

sea. The young of these and of a hundred other forms swarm in the surface water on still evenings, in countless myriads, the most delicate creatures, many of them as transparent as glass, and so small that it requires a microscope to see them. After passing through metamorphoses more wonderful than any described in the tales of Ovid, the remnant of this host which nature allows to live, takes on adult characters. The young crab or prawn after having gone by several aliases, and played as many distinct roles, sheds it skin once more, sinks to the bottom and except in point of size is indistinguishable from an adult. One would hardly have guessed that a larva like that of the mollusc with its enormous locomotory sails, and its delicate fringes of cilia, would ever develop into a sedentary slow-moving gastropod, or that the grotesque microscopic larva, shaped like a painter's easel, would ever turn into into a symmetrical starfish with its five horizontal rays.

If one spends a few hours in the gulf stream on a calm day or night, he cannot fail to be impressed by that vast stratum of living beings, which this great ocean current bears hourly upon its bosom. Once when off our southern coast, we sailed through a school of medusæ which must have covered many square miles of ocean. They were little brown .bells, the size of thimbles, and the indigo water was peppered with them. We encountered them at about four o'clock in the afternoon and for more than an hour their numbers did not sensibly diminish. But at night the dark waters glow with the phosphorescence of those minute and obscure beings whose presence one would not suspect by day unless he had microscopic eyes. Through every mile that the ship ploughs her way, her bow encounters a steady stream of shooting stars. Every movement in this living water precipitates a shower of sparks, and every spark is due to an organism. There are stars of the first magnitude, like the large medusæ glowing like red-hot cannon balls, besides a whole galaxy of lesser lights.

Much of the time of a naturalist at the seaside is spent in the collection and study of these pelagic larvæ and the adult forms which they represent. A calm summer's evening when

not a ripple breaks the mirror of the surface, is best for this purpose. With a companion to take turns at rowing, or to hold the net, we glide off in the darkness to some point where a distinct current sets, or better still where two currents meet, for in such places pelagic larvæ are most abundant. The apparatus for "surface collecting" as it is called, is simple enough. It consists of a tow net made of bolting cloth or coarsely woven silk, through the meshes of which the microscopic animals cannot pass, and a bucket of sea water. The net is put out and allowed to skim the surface as the boat moves slowly through the water. If the place and time are very favorable the net soon begins to glow, as if made of platinum gauze, heated white hot, and at short intervals it is cautiously raised to the boat, and the sparks are washed off into a bucket of sea water, and the process repeated. After returning to the laboratory, the water containing the evening's catch is carefully examined by each student, who selects and preserves those particular organisms which he happens to be at work upon at the time.

If a tall beaker of this water is dipped from the bucket and held up to the light we may behold a most remarkable and fascinating sight. Every drop is teeming with life. The myrmidons of the deep are here. The young of almost every type of marine life has a representative in our glass, but so disguised are many in their undeveloped state that only the specialist may recognize them. They vary in size from half an inch long down to microscopic proportions. Some are adults. There are innumerable larvæ of crustacea, of grotesque shapes, moving with quick jerks; some with the body stuck full of spines, or with a huge straight spear growing out of the forehead; glass-like Ctenophoræ reeling through the water, propelled by encircling bands of irridescent cilia; veliger mollusks floating with sails wide spread; bead-like larvæ of annelids, which swim with rapid rotatory movement: the colorless eggs and quaint fish embryos, whose large black eyes and enormous golden yellow yolk sacs, attract the eye while their transparent body is hardly visible; the pulsa-

ting bells of ghost-like jelly-fish, rising and falling as they deliberately contract and expand their discs; the floating Siphonophoræ transparent as the air and delicate as spun glass. In the turmoil of the moment a thousand strangely beautiful forms pass rapidly before the eye.

The larvæ selected for study are carefully set aside in beakers of sea water, or in watch glasses, and it is sometimes possible to keep them alive for a number of days, and observe their transformations, but usually unless there is means of providing them with freshly aërated sea-water, this is not possible. Some forms are so delicate that one is hardly able to bring them in alive. They die as soon as caught.

Where it can be done, by far the most satisfactory method of studying the development or life history of an animal is to procure the adults and keep them under observation until they deposit their eggs. The development of the ova can then be studied with the closest detail, not only by the superficial view of the growing embryo, but by means of the sectional method which has yielded such valuable results to natural science in the past ten years.

In the case of many animals, such as fishes, "king crabs," oysters, starfish, and sea urchins, where the sexes are separate, the ripe eggs can be obtained and fertilized artificially, and the complex processes by which the highly organized fish or mollusc is slowly built up by changes which start in the germ cells, can be witnessed in all their details. Animals differ very widely in this respect however, and the vitality of the ova is connected in some cases certainly with that of the animals themselves. Starfish or Ophiurans may be sadly mutilated without killing them, and some of the molluscs are notoriously hardy. A year and a half ago I brought from the West Indies a collection of marine shells, gathered in the water or on the coral rocks on shore. They were done up in a package and sent with other collections to my home in New Hampshire. The next fall when the bundle was opened, much to my surprise a number of the univalves (*Tectarius muricatus*), were alive and crawling about. In one of our eastern colleges,

some molluscs brought from the Holy Land were placed in the college collection and duly labelled, when some of them exhibited their vitality by walking off the museum cards.

The "Horseshoe," or King Crab which anyone who goes to the Atlantic seaboard can usually find on any sand-flat, is an animal remarkable not only for its great antiquity, but for its extreme hardiness which is perhaps one cause of its great age. They are found fossil in the primary rocks, in the Cambrian and Silurian formations, and therefore excepting the Foraminifera, they are among the oldest animals known. The related trilobite has perished utterly, and a whole army of other forms, but the King Crab has existed during all these ages and has altered but little; hence we must infer that their conditions of life have been nearly uniform during this immense period. When the embryology of this animal was being studied at the Marine Laboratory of the John Hopkin's University at Beaufort, N. C., a few years ago, an attempt was made to fertilize the eggs artificially. As the ova did not at first show any of the usual signs of development, but began to swell as if undergoing decomposition, they were set aside and forgotten. In about 3 weeks from this time the dish was examined by chance, when it was seen that the young king-crabs were just leaving the shell, notwithstanding the fact that the water in which they had lived was impure, and had nearly evaporated. The following anecdote which illustrates what the adult King Crab can stand, I heard from Professor Brooks of the Johns Hopkins University. While he was studying with Louis Agassiz at Cambridge, Milne-Edwards, the renowned French naturalist sent to this country for some specimens of the American King Crab, on which he was then preparing his well known monograph. The animals as soon as captured were taken to the Cambridge laboratory and thrown under a building, where they remained some weeks, exposed to a low temperature. They were then packed up and sent abroad, and when they reached Paris, some of them were still alive. It is interesting to notice that this animal is not a Crab at all, nor indeed a Crustacean, as the recent study of its development has

most certainly shown. It is more nearly related to the Spiders.

The case is very different with the ova of many other animals, for instance the eggs of prawns such as the Lobster and the Shrimp. They are not discharged into the sea, and left to take their chances with enemies, but are attached to the body of the animal which carries them about until they hatch. In most cases they are fastened by fine threads of glue to the swimming legs, and as the constant motion of these appendages is shared by the eggs, the latter are always well aërated. If the ova are removed from the animal, they invariably die.

Some Crustacea (like the Stomatopods) lay their eggs in masses in burrows in the sand or in coral rocks, and if they are removed and placed in an aquarium, they also die. But if the habits of these animals are studied, it is found that either the male or female is always brooding over the eggs and fanning them with its legs, thus supplying the needed aëration by the currents of water set up. This process of supplying the necessary oxygen is seen in fish-hatching houses, where the eggs are laid upon shallow trays, over which a stream of water is constantly passing.

The eggs of animals like the Corals and Sea-fans can be easily obtained in the breeding season, by placing a colony of the polyps, like a piece of living coral, in a glass dish or aquarium. The minute spherical eggs or young will be discharged through the mouths of the polyps and float to the surface, when they can be skimmed off, transferred to other dishes and their development watched. With the modern appliances and methods of research, the naturalist of to-day can investigate the problems of animal life with far better success than was possible a generation ago. How is the life history of an animal written? How do we trace the numerous links in the chain of events between the one-called, apparently homogeneous egg, to the highly complex animal which produces the egg? To answer this question very briefly we may conveniently select the shrimp, although we might choose equally well a fish, a sea-urchin or a coral.

It is well known that the eggs of the higher animals, the mammals, are few in number, and that when fertilized, they are not discharged, but remain and develop in the body of the parent. Partly for this reason the embryology of the higher forms is much more difficult, but the eggs of the lower animals, like Crustacea, Corals and Starfishes, are deposited in very great numbers. The number of eggs laid by the edible Crab (*Neptunus hastatus*) of the Southern States, for instance, is estimated at 4½ millions. The eggs are not only passed out of the body, but in many cases develop quite independently of the parent. Consequently a store of food called *yolk*, is laid up in the egg, as we see in the hen's egg, for the use of the growing embryo.

We start with the fertilized germ cell the egg, although it should be remembered that there is a long series of events before this is reached. The germinal cell itself is derived from other cells in the tissues of the mother and the tissues which compose the body, are themselves derived from the egg, and this cycle is repeated generation after generation. The male germinal cell, which in fertilization unites with the ovum, has a similar origin, so that the egg, from which the animal springs is not as simple a structure as one might suppose, but a microcosm in itself, containing as it must the hereditary germs of a long and complex line of ancestors.

As a rule an egg does not develop unless it unites with another kind of cell, called the male germinal cell. This rule is however violated, in the case of the parthenogenetic insects, the Gall-wasps, Bees and Moths, and in some Crustacea, where the eggs develop without fertilization, and where the males are sometimes wanting.

The egg of the shrimp, like that of the hen or tortoise consists of a large mass of food-yolk, surrounding the more essential part of the cell,—the nucleus, as it is called, the whole being enveloped by a protective membrane, the shell. Beginning then with the single egg-cell (which, if fertilized, is of course duplex in nature,) the animal is slowly developed by the division and differentiation of its products. The nucleus and

sometimes the whole egg with it, divides into 2, 4, 8, 16 parts in geometrical ratio. The resulting cells however do not separate as in the lowest forms of life, but remain united, and do not long continue alike but become differentiated. A very complex physiological division of labor is finally established among them, and when the adult condition is reached, the body is a colony of probably many million of cells, constituting various tissues and organs, all of which work correlatively and harmoniously for the good of the whole. The adult healthy body may thus be compared to an ideal state, where the cells represent individuals or individual minds, all of which have the same faculties, although developed in different degrees. Yet all these subordinate units work together in a wonderful way for the good of a higher unit, the body or state. As the state has its executive and police officers to guard its interests and enforce obedience to its laws, so the body has the nerve cells of the nervous system, which in health regulate and coördinate the working of all the other organs.

This fundamental conception of living things, known as the Cell Theory, was announced 50 years ago. It is no longer a theory but a fact, and from it every problem in biology must proceed.

How then is it possible to follow these delicate and intricate processes by which the complex cell-state or community, which we call the animal, is developed from the egg? The changes are chiefly internal, while the eggs, which are usually of microscopic size, are frequently opaque, and the protoplasm or living matter of the cells themselves, is colorless. Difficulties such as these, however insurmountable they may have been a generation ago, have been completely overcome, and it is now an easy task to divide an egg, which we will say is 1-25 of an inch in diameter, or the size of a pin's head, into a series of 100 sections, each 1-2500 of an inch in thickness. These may then be placed in serial order on a strip of glass, and each of the 100 sections, which can now be studied with high powers of the microscope, is seen to be a picture in color, which plainly tells of the marvellous processes which have

been going on unseen in the colorless living protoplasm of the cells.

The eggs of our Shrimp are taken at short intervals during several days or weeks, so that the series will represent the whole history of growth from the egg to the young prawn. The ova are then killed and hardened by suitable reagents, and finally preserved in alcohol. They are then stained with certain dyes like carmine, hæmotoxylon, or osmic acid (which both kills, hardens, and stains protoplasm at the same time). A great step was taken in modern biology (and especially embryology) when it was discovered that protoplasm has such a remarkable affinity for the aniline and vegetable dyes. The colorless and invisible can be made to yield the secret of hidden change in colored pictures. Furthermore it is probable that certain kinds of protoplasm, or protoplasm in certain stages combines only with particular dyes.

The stained eggs are then saturated with paraffine and embedded in a block of this substance. The paraffin block is clamped in the holder of a microtome, an instrument for cutting very thin sections, and then, thanks to the property of the paraffine, each section, as soon as cut by the passage of the knife, adheres by its edge to the section following, so that a paraffine ribbon can be cut, a yard long if necessary, in which the embedded egg will now appear in the form of a series of very thin colored sections, arranged in serial order. It is then a simple matter to fix them upon a glass slide, to remove the paraffin, and to seal the whole in a drop of balsam. Thus may we bring out the hidden writing and read the secret manuscript.

We have not the time to follow in any detail the life history of an animal like the Shrimp, however interesting it might be, to see how from the simpler the complex arises, how the adult with its tissues and organs each so remarkable and often complicated in itself, arises from comparatively simple beginnings, and how the individual in its own life history repeats in an abbreviated and modified form, the history of the race. But we do well if we realize this wonder of wonders, the development

of the higher animal with its marvellous organs, the eye, the heart and brain from the egg cell. If the eye or the brain is complicated, what must we say of this unicellular germ, the egg, in which in large measure certainly, the adult structure must potentially exist.

Some may think that since the young of different animals are subjected to peculiar conditions, to varying climate, food and the like, their differences in structure may be influenced by their surroundings. But this objection is easily answered, for we can rear the eggs of such diverse forms as the fish, the sea urchin, and the oyster in the same tumbler of water, where the conditions are identical. We are thus brought face to face with the great problem of *heredity*, that is, the law by which all living things tend to resemble the parents from which they sprung, or some ancestor belonging to their immediate race, in spite of variability or adaptation to environment. That the coral polyp reaches a certain stage of development and stops, that the starfish travels by this same road but advances far beyond, the young always coming to resemble the adult; that the higher animals pass still farther along this path; that the child resembles its parents often to a trick of speech or to a shade of mental or moral character, or that sometimes the character of a preceding generation makes its appearance, is one of the most remarkable phenomena which man has observed. Marvellous as it is, it seems not to be inscrutable, and the studies of recent years are lightening its dark passages.

It may be asked, of what use is the knowledge of the structure and development of animals below man. The chief aim in natural science is to discover relations. The life history of a coral is valuable for the light it throws on the problem of all organic life. The great laws governing all living matter are the same. We can only read the complex through the simple. The lower we pass in the scale of animal and plant life, the simpler the structure, the more nearly are the problems reduced to lowest terms.

The most interesting object in nature is man, and apart from the high claims of pure science, of knowledge for its own merit,

our studies naturally come to a focus in man. The history, the welfare and the destiny of man are questions which interest all civilized people.

Biology or the natural history of living things deals with the phenomena of organic nature, and to man, its central figure it constantly returns. Morphology, the study of structure, physiology the study of function, pathology the study of disease, and medicine the study of treatment go hand in hand, and are mutually dependent. We sometimes hear well meaning though misinformed persons speak of naturalists who spend laborious years of travel and devote their lives to research as if they were bitten with the mania of discovering new species. This is, of course, a great mistake. The history of every science begins with the naming of things, but this day is long past, and as Agassiz said in one of his cabin lectures when on his way to Brazil in 1865: "This is now almost the lowest kind of scientific work." . . . . "The work of the naturalist, in our day, is to explore worlds the existence of which is already known; to investigate not to discover." . . . . "The discovery of a new species as such, does not change a feature in the science of natural history, any more than the discovery of a new asteriod changes the character of the problems to be investigated by astronomers. It is merely adding to the enumeration of objects. We should rather look for the fundamental relations among animals; the number of species we may find is of importance only so far as they explain the distribution and limitation of different genera and families, their relations to each other and to the world under which they live. Out of such investigations there looms up a deeper question for scientific men, the solution of which is to be the most important result of their work in coming generations. The origin of life is the great question of the day. How did the organic world come to be as it is?"

A generation has passed since these words were uttered, yet how true they still read! Much indeed has been accomplished in this period; the horizon of all science has widened. The germ theory of infectious disease has become a science and is

now revolutionizing the practice of medicine and surgery.

Says a well-known physician "Looking into the future in the light of recent discoveries, it does not seem impossible that a time may came when the cause of every infectious disease will be known." . . . . "What has been accomplished within the past ten years as regards knowledge of the causes, prevention, and treatment of disease far transcends what would have been regarded a quarter of a century ago as the wildest and most impossible speculation." Embryology has been enriched by the discovery of new means of research. Some of the best work in physiology has been done. Darwin's theory of the origin of species has been tested as a working hypothesis, and been found fruitful in valuable results. The work of the naturalist by its application to the economic industries of the nation can appeal to all classes. The service of the Fish Commission and of the Entomological Bureau annually save the country from great losses, and add to its resources. Our valuable food fishes are artificially raised, and the depleted pond, river or sea coast can be stocked anew. The oyster can now be reared from eggs artificially fertilized, and the young lobster has this last year been safely transported across the continent, and planted on the shores of the wide Pacific.

But the study of nature has another and less serious side, and here I refer to out-door nature as well as to in-door pursuits. It adds pleasure to life. It gives a zest and object to every walk or ride which one takes in the open air, to every camping and hunting excursion to the woods. It lengthens life, or what is the same thing, our experience, because we see just so much more of this beautiful world. Many people think that science is not only difficult but dry. This is a sad mistake. The scientific treatises which Charles Lamb would class with books that are *not* book, may be tedious to the beginner, but the student is not restricted to these or to the musty folios of the past, in making his acquaintance with animal and plant life. Technical works are not intended to be read but, like dictionaries, they are useful to consult.

"Botany," says Sir John Lubbock, "is by many regarded

as a dry science. Yet without it one may admire flowers and trees as one may admire a great man or a beautiful woman whom one meets in a crowd; but it is as a stranger. The botanist" or "one with even the slightest knowledge of that delightful science—when he goes out into the woods or into one of those fairy forests which we call fields, finds himself welcomed by a glad company of friends, every one with something interesting to tell."

The faculty of observation, so preternaturally acute in some minds like Aristotle's or Humboldt's or Darwin's, is rudimentary or dormant in a very large part of mankind. Said Emerson "if men should see the stars but once in a thousand years how would they wonder and believe!" The cheapness of the pleasure may be fatal to its enjoyment. They see only the mud and soot, where the gold and the diamond lie. They have eyes but do not use them, and like Laura Bridgman are cut off from many of the enjoyments of nature. As Lubbock well says, many still "love birds as boys do—that is, they love throwing stones at them; or wonder if they are good to eat, as the Esquimaux asked of the watch; or treat them as certain devout Afreedee villagers are said to have treated a descendant of the Prophet—killed him in order to worship at his tomb."

The study of Natural History, or Biology, if we use the newer term not only awakens the mind by cultivating the faculty of observation, but widens our enjoyments and enlists our sympathies, giving us a new and human interest in the manifold living beings around us which hold life by the same tenure as ourselves. It also fits in well with those instincts which we seem to have inherited from primitive man, with hunting and fishing, and also with travel, the facilities for which were never greater than in our day, and with short vacations in the country, all of which it enhances in interest, and to all of which it insures success.

Says T. Digby Pigott, "Of all the poor creatures, whose fate it was to be strangled or battered to death by Hercules, there was only one who made a really good stand up fight, and at one time seemed to be fairly beating him. He was Antaeus,

the son of the earth. Every time that he fell and touched his mother—we should say 'ran out to the country'—he came up again with fighting powers renewed. It was not till Hercules found out his secret and held him up, never letting him fall—we should say 'stopped his Saturdays till Mondays out of town'—that he quite broke him down. It is a myth in which the wisdom of the ancients is written for our admonition, in whom the ends of the world have come, the lesson that the best cure for a tired head and irritable nerves is the touch of Mother Nature,—to escape from the din of the city, and the everlasting cry of 'extra specials,' and lose oneself if only for a day among the wild creation."

The life and structure of the simplest animal or plant is a marvel, the greatness of which we are utterly incapable to conceive, and one of the plainest teachings of everyday science is that mere *size* is no test of importance. One might suppose that the microscopic cell was too small to be taken into account at all and to spend days and nights in the study of such objects must be a stupid sort of amusement: But an Elephant is only an aggregate of these little cells, and the nefarious microbe or floating spore, so small that it takes the highest powers of the best microscopes to clearly discern it, and so light that it floats in myriads on the wings of the viewless air, it is also a cell, and unfortunatly for man, when breathed into his lungs may be capable of multiplying indefinitely, and producing terrible disease and death. The coral polyp, insignificant enough when contemplated singly, is able to girdle the globe, only give it the time and favorable conditions. The leaven however small, which is hid in the meal, will in due time leaven the whole lump.

The mountains were not upheaved in a day. The hills have been carried by the touch of the rain-drop, and the flow of the ice stream and river. The smallest fragment of coral rock, which is among the youngest of modern formations, is but a phase in the endless cycles through which all matter runs. The rain united with the carbonic acid of the earth and air divides the solid rock, and the rivers from the four corners of

the earth carry down the molecules of lime in a ceaseless current with the common sea, where says Dana "after circulating over thousands of miles and for unknown times, they are brought to light and rendered tangible again by the incessant labors of millions of minute living gelatinous bodies, and by these insignificant organisms the lime is built up again into masses almost rivalling the original in dimensions and importance, but losing in this, its new dress, all traces of its divine origin and divine age." Thus he says, "we may have rocks from the snow-covered summits of the Himalayas, the limestones of the burning plains of India, and the strata of inaccessible China, removed from their respective districts—into the great common receptacle."

Modern science teaches that the small has produced the great, that the earth as we now know it has been fashioned by forces which are in operation to-day. The small indeed may be the most significant, and size in the vocabulary of biology at least may be an unimportant term.

SOLENISCUS: ITS GENERIC CHARACTERS AND RELATIONS.

BY CHARLES R. KEYES.

THE genus Soleniscus was established by Meek and Worthen to include gastropod shells closely allied to the widely known Macrocheilus; and said to be distinguished from the latter chiefly by the presence of a single elevated fold on the columella and by being produced anteriorly into a short canal. The authors described under this genus but a single species—*S. typicus*. Miller,[1] however, in 1877, included also *Macrocheilus hallanus* Geinitz. Four years later White[2] described from New Mexico *S. planus* and *S. brevis*; and afterwards[3] referred to the genus five other species which had orig-

[1] Am. Palæ. Foss., p. 162.
[2] Exp. and Sur. west 100th Merid., Supp. to Vol. iii.
[3] Ind. Geol. Rep. for 1883.